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ABSTRACT

The CET (Civil Engineering Technology) project was a statewide curriculum development effort to develop an instructional format to train civil engineering technicians in South Carolina. It was designed to: (1) identify specific job competencies; (2) develop an individualized, self-paced instructional format complete with software and equipment; and (3) test and validate all items being developed. This report offers background information, describes the curriculum that was developed, and summarizes the result of the project evaluation. (EMH)

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PROJECT CIVTEC: A STATE-WIDE CURRICULUM DEVELOPMENT

PROJECT IN ENGINEERING TECHNOLOGY

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STATE BOARD FOR TECHNICAL AND COMPREHENSIVE EDUCATION
COLUMBIA, SOUTH CAROLINA

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INTRODUCTION

In 1972, the South Carolina General Assembly passed Act 1268 which created the State Board for Technical and Comprehensive Education. The newly created State Board replaced the existing State Advisory Committee for Technical Training and was given jurisdiction over all two-year, state supported, post-secondary institutions and programs except for the University of South Carolina and Clemson branch campuses. During its formative years as an advisory committee and following its elevation to Board status, the system grew to its present total of sixteen technical colleges and centers (see Figure 1). Under the supervision of local area commissions and the guidance of the State Board, these institutions provide a comprehensive state-wide educational system (TEC). The underlying theme for the development of TEC has been its commitment to train highly qualified technicians to meet the needs of new and expanding industry.

Over the years, TEC has become a strong leader in technical education offering the advantage of a built-in consortium with an aggressive State Board providing leadership to the sixteen institutions as they in turn provide valuable technical training for the people of South Carolina.

Typical of the developmental leadership the State Board provides for the system is the state-wide curriculum development project in Civil Engineering Technology. In 1973, the State Board, through its Division of Educational Services, received a National Science Foundation grant to develop an individually-paced instructional format for the state-wide Civil Engineering Technology curriculum in South Carolina. The grant was funded for thirty-nine months and is administered through the Foundation's Science and Engineering Technician Education Program.

The project was designed to accomplish three basic objectives:

1. to identify the specific competencies required of a civil engineering technician,

2. to develop an individualized, self-pacing instructional format complete with software and equipment, and

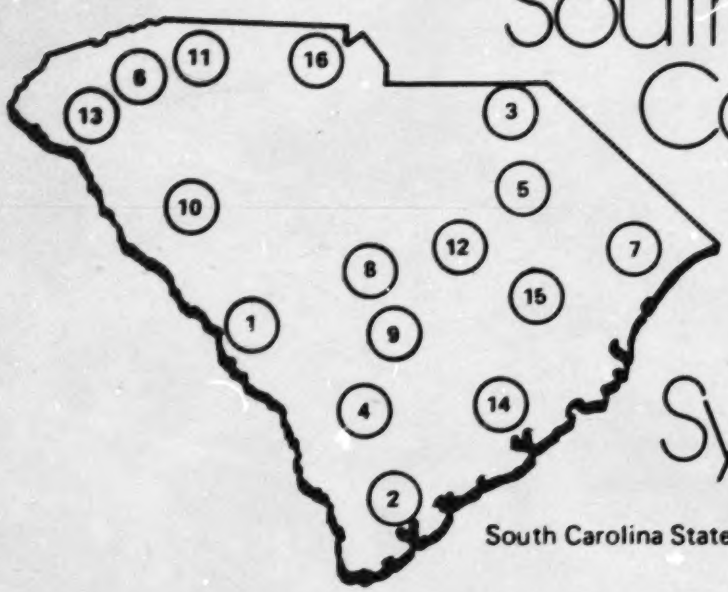
3. to test and validate all items being developed.

The ultimate goal of the project is to develop a learner-oriented, open-entry/open-ended instructional format which relies heavily on the uses of audiovisuals and hands-on experience.

SIGNIFICANCE AND SCOPE OF THE ORIGINAL PROPOSAL

The original project, as funded by NSF, addresses itself to several educational problems of national concern, specifically student recruitment, attrition, and the problem of dealing with varying student ability levels within a given course curriculum. The concept of the individually-paced curriculum in this project is directly aimed at the alleviation of such problem areas.

It is hypothesized that the need to seek out and recruit interested students will be aided by an individually-paced curriculum which would enable a student to enter the program at any point during the year even though the introductory courses might not normally be scheduled at the time he wishes to enter. Furthermore, the inherent flexibility of the individually-paced curriculum is particularly valuable in enticing working students and others who may need to make special time arrangements not possible under traditional education programs.



South Carolina's Technical Education System

South Carolina State Board for Technical and Comprehensive Education

TECHNICAL EDUCATION

1 Aiken Technical Education Center
Post Office Drawer 696
Aiken, South Carolina 29801
Phone 593-9231

2 Beaufort Technical Education Center
100 S. Ribaut Road
Beaufort, South Carolina 29902
Phone 524-3380

3 Chesterfield-Marlboro Technical College
Drawer 928
Cheraw, South Carolina 29520
Phone 537-6286

4 Denmark Technical Education Center
Denmark, South Carolina 29042
Phone 793-3301

5 Florence-Darlington Technical College
Post Office Box 8000
Florence, South Carolina 29501
Phone 662-8151

6 Greenville Technical College
Post Office Box 5616, Station B
Greenville, South Carolina 29606
Phone 242-3170

7 Horry Georgetown Technical Education Center
Post Office Box 710
Conway, South Carolina 29526
Phone 347-3186

8 Midlands Technical College

Airport Campus
West Columbia, South Carolina 29169
Phone 796-8401

Beltline Campus
316 Beltline Boulevard
Columbia, South Carolina 29205
Phone 782-5471

9 Orangeburg-Calhoun Technical College
Post Office Drawer 1767
Orangeburg, South Carolina 29115
Phone 536-0311

10 Piedmont Technical College
Drawer 1287
Greenwood, South Carolina 29646
Phone 223-8357

11 Spartanburg Technical College
Post Office Drawer 4386
Spartanburg, South Carolina 29301
Phone 576-5770

12 Sumter Area Technical College
506 Guignard Drive
Sumter, South Carolina 29150
Phone 773-9271

13 Tri-County Technical College
Post Office Box 87
Pendleton, South Carolina 29670
Phone 225-2250

14 Trident Technical College

North Campus
7000 River Avenue
North Charleston, South Carolina 29406
Phone 553-2375

Palmer Campus
125 Bull Street
Charleston, South Carolina 29401
Phone 722-0531

15 Williamsburg Technical, Adult and Vocational Education Center
P.O. Box 640
Kingstree, South Carolina 29556
Phone 354-7423

16 York Technical College
U.S. Highway By-Pass 21-A
Rock Hill, South Carolina 29730
Phone 328-3843

Figure 1. Location of South Carolina's sixteen technical education colleges and centers.

Another hypothesis of this project is that the diversity and resultant enthusiasm generated by a creatively engineered, individually-paced curriculum will attack the problem of student attrition more efficaciously than the traditional teacher-oriented approach. A student using an individually-paced packet of learning materials is made aware of the objective and the necessity of each unit being studied and is thereby involved in the total learning process rather than simply being the recipient of it. The "hands-on" experiences aimed for in this project can transform theory into reality for the work-oriented student. The diversity of the learning techniques utilized within the self-paced curriculum is directed at the creation and retention of student interest in the various subject areas being covered. Should a student fail to meet necessary course objectives, the individually-paced concept gives him a viable alternative to dropping out of the program by enabling him to repeat courses or segments of courses without suffering the loss of time which usually accompanies the repetition of a course.

It is further hypothesized that the individually-paced curriculum will positively affect the students' level of success by recognizing and allowing for their individual abilities within any given area. Under this concept, a student can be met at his present level of proficiency, and progress from that point at his own rate.

Furthermore, not all students learn best by listening and reading. The instructional format implemented under this student-oriented strategy is designed to provide a multi-media approach to learning in an attempt to successfully reach students with varying degrees of verbal skills.

An adequately developed individually-paced program should allow students to independently choose, initiate, and follow through a specific learning technique on a given subject, thus allowing the instructor to serve, not as the traditional disseminator of knowledge, but rather as a resource expert in the field who is able to give individual attention when needed.

ORGANIZATION AND ADMINISTRATION

The project was staffed with a Director in March of 1973. Soon after, the faculty in the ten institutions which offer the Civil Engineering Technology (CET) program were organized to form a nucleus of course content experts.

An Associate Director was employed in June of the same year to coordinate the development of audiovisual materials. Preliminary meetings of the organized faculty unit resulted in agreement on the courses that would constitute the core curriculum in Civil Engineering Technology.

The courses included in the core curriculum and adopted as target areas for the project are:

1. Statics
2. Strength of Materials
3. Structural Concrete
4. Structural Steel
5. Surveying I
6. Surveying II
7. Cost Estimating
8. Highway Design and Construction
9. Hydraulics
10. Water and Sewerage Systems
11. Soil Mechanics

DEFINING COMPETENCIES

When a consensus had been reached by the faculty members concerning the specific courses to be developed, the project staff set about determining the core content of each course. To accomplish this objective, a series of meetings was held with the faculty committee. In preparation for these meetings, each school was asked, through their civil engineering Department Heads, to submit their existing course objectives. These objectives were reproduced and complete sets were returned to all CET faculty members so that each instructor was aware of other programs within the consortium. During subsequent faculty meetings, each instructor participated in the process of identifying those objectives which should be consistent among all ten schools. The end result of this series of meetings was a comprehensive task analysis of the core curriculum which resulted in a collective list of 163 competencies for the eleven courses in the CET program.

The next task was to verify that the 163 competencies identified by the consortium faculty were consistent with the needs of potential employers throughout the state. A second round of meetings was organized between representatives of faculty and industry. Although time consuming, these meetings provided a valid and realistic list of competencies required of a civil engineering technician.

SELECTING A FORMAT

By June of 1973, the preliminary task analysis had been completed and a format for writing the instructional material for each course needed to be selected. Since most of the available texts relating to the project's areas of concentration are written for the student seeking a baccalaureate degree, it was decided that the instructional units must be self-contained with little or no reliance on existing texts. It was also decided that the instructional units should be based on the concept of mastery learning with heavy emphasis on hands-on experience. After a careful analysis of our needs and the available predetermined methods for preparing self-instructional materials, the techniques developed by Drs. Stuart and Rita Johnson, Chapel Hill, North Carolina, were selected. Basically, their system is designed around a self-instructional book that has been written to guide an instructor through the process of producing and testing a small self-instructional unit or package. This book, entitled *Assuring Learning with Self-Instructional Packages or Up the Up Staircase*[1], was the focal point of a workshop for the faculty organized in June 1973, to:

1. introduce or reemphasize the concept of mastery learning to all the faculty,
2. identify the strongest supporters of the project, and
3. identify potential writers for the project.

With the list of identified competencies, an acceptable writing format, and the faculty involved and familiar with the project, we were ready to begin writing.

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[1]Johnson, Stuart R. and Rita B., *Assuring Learning with Self-Instructional Packages or Up the Up Staircase* (Reading, Mass: Addison-Wesley Publishing Co., 1973).

SELECTING THE WRITING STAFF

Since the development of the materials would necessitate a thorough knowledge of the entire spectrum of the civil engineering curriculum, it was decided that the writing could best be accomplished by subcontracting several course content specialists. A major decision concerning the method of writing dealt with the problem of whether to contract the writing to highly trained content specialists outside the system, or to use exclusively the pool of system-wide instructors with their more general backgrounds and experiences. Content specialists offered the advantage of more developed writing skills combined with a knowledge of the most current technical information. The faculty members, on the other hand, were familiar with the capabilities of the students for which the material would be prepared. Additionally, instructors at each institution, through continued close contact with their preestablished local industrial committees, could evaluate instructional content according to the needs of industry.

The results of the first workshop showed that approximately seventy-five percent of the faculty members were extremely interested in the project and eager to participate in the writing. Because of the high percentage of willing faculty participants and their understanding of the student population as well as local industrial needs, it was decided that faculty members should be the principal authors of the Civil Engineering Technology curriculum with the University of South Carolina faculty serving as consultants. This approach offered the advantages of both groups. It provided the project with material prepared for technology students by technology instructors and edited and proofread by highly trained specialists. Occasionally, this approach was somewhat more time consuming than anticipated since portions of the original material required substantial revisions. However, it did provide a method for maintaining accountable instructional materials, and consequently, it was well worth whatever additional time was requried.

DEVELOPING THE WRITTEN MATERIALS[2]

A key project strategy for the development of instructional material is to maintain a degree of flexibility that will allow rapid movement to compensate for needed talent on a short-term basis. For example, the approach selected for this project has been to maintain a small core of full-time professionals at the State Board to administer and coordinate the material development and to supplement the authors' efforts with consultants and part-time employees. This arrangement has been successful since there are specific talents required to write each course. Hiring supplemental help as needed allows the Project Director to design a staff around the characteristics of the course and its author.

Generally, the part-time help that has been required falls into one of the areas listed below:

1. artist/cartoonist
2. technical illustrator
3. technical editor
4. script writer

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[2] Figure 2 depicts the basic developmental steps taken for each course.

	SURVEYING I	SURVEYING II	STATICS	HIGHWAY DESIGN	COST ESTIMATING	STRENGTH OF MATERIALS	STRUCTURAL STEEL	REINFORCED CONCRETE	SOIL MECHANICS	HYDRAULICS	WATER AND SEWERAGE
CONCENSUS ON COURSE CONTENT											
CONTRACT WRITER											
COURSE OBJECTIVES DEVELOPED											
STAFF REVIEW OF OBJECTIVES											
REVIEW BY INDUSTRIAL REPRESENTATIVES											
WRITTEN MATERIAL IS DEVELOPED											
STAFF REVIEW AND EDIT											
BASIC ILLUSTRATIONS ARE INCORPORATED											
REVIEWED BY REVIEW COMMITTEE											
STAFF INCORPORATES REVIEW COMMITTEE											
COMMENTS AND EDITS											
TYPED FOR WALK-THROUGH											
ADD PHOTOGRAPHS AND OTHER ILLUSTRATIONS											
PROOFREAD											
ARRANGE FOR WALK-THROUGH--CLASS OF 6-10											
CONDUCT WALK-THROUGH											
EVALUATION BY STAFF, STUDENTS AND FACULTY											
IDENTIFY PROBLEM AREAS											
DEVELOP NEEDED SUPPORTING MEDIA IF REQUIRED											
REVISE WRITTEN MATERIAL IF NEEDED											
COORDINATE WRITTEN MATERIAL AND MEDIA											
PRINT FOR FIELD TEST											
FIELD TEST COMPLETE WITH SUPPORTING MEDIA											
	← PHASES I & II 27 MO. →								PHASE III 12 MO.		

Figure 2 - Itemization of the developmental steps taken for each course.

All individuals employed under these circumstances are contracted and compensated on a per unit produced basis. In all cases, remuneration is made only upon successful completion of the objective and acceptance of the work by the Project Director.

The first step in the development of the written materials was to conduct an evaluation of interested TEC faculty members to determine the most qualified person to write the material for each subject area.

A detailed contract was signed with each author as the writing of instructional material for the competencies associated with each course was assigned. The contract outlined the specific procedures and deadlines each author must follow in submitting his work. There were also quality requirements with built-in checks to guarantee the highest quality of work possible from each author. The contract also included procedures to follow in case either party wished to withdraw from the contract for reasons of unresolved disagreements or inability to complete the work. Thus far, this portion of the contract has been used only twice. In both cases, the problem was easily and satisfactorily resolved since both parties understood the procedure before entering into the contract.

Under the provisions of the contract, the author's first duty is to develop a list of objectives from the existing competencies for his content area. These objectives are scrutinized by the project staff and the instructors from participating institutions. When complete, each objective then becomes the theme around which an instructional module is developed.

Before a rough draft of each module is accepted, it is reviewed by the project staff and a select group of institutional faculty. At this stage of development the review is conducted to determine the accuracy of the content and the appropriateness of the sequencing. No attempt is made at this point to judge the module's classroom effectiveness. Each author is obligated to conduct one revision, if required, as part of his contractual obligation.

EVALUATION OF THE WRITTEN MATERIALS

As the written material for each course is completed, the long process of validation by field test begins. Each module is first scrutinized by a consultant from the University of South Carolina who is an expert in that particular area. The purpose of this edit is to utilize the writing skills of highly trained experts to rewrite or reorganize any weak points in the module.

The next step involves identifying an instructor and a group of students to participate in the field testing of each module.

Although conducted under less than ideal conditions, the project's main concern with field testing is to attempt to validate self-instructional material in a conventional classroom setting which provides the opportunity for thorough observation of student reaction to each module.

When possible, the project staff monitors the class and records the questions and comments of all students as they progress through the modules. When a project staff member cannot attend a "walk-through" class, the instructor is asked to record the necessary information on a form. Although using instructors to record student reactions expedites this phase of evaluation, it has proven to be less informative than the reactionary data obtained by project staff members who, unhindered by the individual problems which must be handled in a class of ten to fifteen students, are free to direct their entire efforts to the evaluation process.

The results of this phase of the development process are extremely helpful in the revision of problem areas within the modules. A careful analysis of student comments provides insight into

those areas in the module which confuse or are misunderstood by the students. These problem areas are closely examined by the project staff to determine if the written material lacks adequate instructions or is improperly sequenced, and if required, the module or parts of it are edited for a second time. If the problem module is ascertained to be well written and content valid, the difficulty encountered by the students will generally lie in the complexity of the concept or in the method of presentation.

For example, some concepts within the module could be rewritten in greater detail thereby helping those students who have difficulty understanding the material. However, addition of more material frequently makes that portion of the module too long and boring for the majority of students who have no difficulty understanding the information in its original form. In these cases, alternate forms of instruction are required to support the printed modules. For example, there are instances encountered during walk-through analysis where a larger number of visuals than is practical to include in the written module would help illustrate a difficult concept.

MEDIA DEVELOPMENT

Although the grant makes specific reference to heavy reliance on multi-media, the position taken by the Project Director has been to allow the instructional effectiveness and the cost determine the medium to be used. If, for example, a concept can effectively be learned through the medium of printed material, the most inexpensive form of media, then it is difficult to justify spending large sums of money to develop the same concept in a more expensive format.

The basic format for each course is a combination of written modules that form a linear progression through a series of related objectives. The linear progression of written material is broadened by a series of alternate media developed for points of difficulty as identified by the analysis of the walk-through results. As illustrated in Figure 3, these alternate media forms provide a branching effect for the student who has difficulty understanding the concept in its more condensed version in the module.

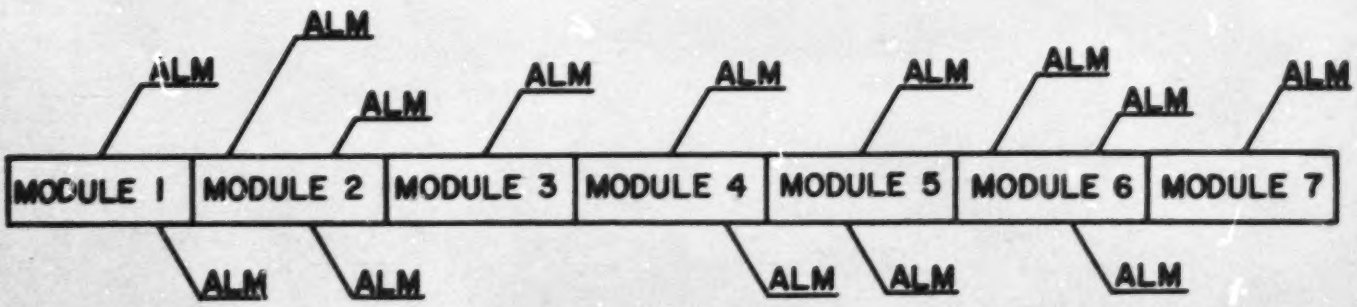

Figure 3. The use of alternate media forms to supplement written modules.

Each supplemental presentation takes a part of the module, usually a single task or concept, and expands the information in great detail, thereby offering the student an alternate learning method. It is, however, possible for a student who encounters no difficulty working through the module to complete a module or modules without utilizing any of the supplemental film presentations. It is also possible that the results of the walk-through may show that no additional support material is required.

As the results of the walk-through began to show evidence of needed supplemental material, the project staff began examining alternate media forms that could be utilized. At this point in the development, the only decision that had been made was to shift from the written format used for the modules to a non-reading visual format. The criteria of effectiveness and cost were again used to evaluate visual formats such as 35mm slides, super eight and video tape.

Two issues associated with learning effectiveness had to be resolved:

1. advantages of still frame vs. motion, and

2. advantages of color vs. black and white.

Four issues relating to cost had to be resolved before a final decision could be made:

1. cost of production and reproduction of media presentations,

2. cost and ease of making revisions and corrections,

3. quantity and type of audiovisual equipment existing in the ten participating institutions, and

4. type of hardware necessary to implement presentations.

Resolution of these questions resulted in the conclusion that 35mm color slides were the most efficient and least expensive of the commonly available formats. Except for limited occasions, still frame is just effective as motion and the cost of 35mm slides is considerably less than super eight or video tape. Also, since there has been research supporting the concept of learning through the use of color, it was decided that the additional expense for color slides could be justified. The 35mm slides also offered the advantage of lower reproduction costs.

Another significant factor that influenced the decision was the ease with which slide-tape shows could be revised. This advantage was considered valuable since it is the intention of the project staff to develop flexible, easily edited materials that are free of the built-in limitations inherent in hard-bound, expensive texts and films.

Finally, an analysis of existing hardware in the ten participating institutions and the purchase price of new equipment also supported the adaptation of 35mm sound-slide format.

Once the medium had been selected, the format for the presentations could be developed. It was decided that to be consistent with the philosophy of mastery learning, the student must have the prerogative of reviewing the material presented. Therefore, the sound-slide presentations would be developed in the same cyclical style as the modules. As illustrated in Figure 4, information would be introduced, a question would be asked to reinforce the information, and immediate feedback would be provided. If a student missed a practice problem, he would be instructed to back-up

several frames for a review. This technique provides a cyclical effect to an otherwise linear program. The addition of the media presentation made a complete instructional program for each course.

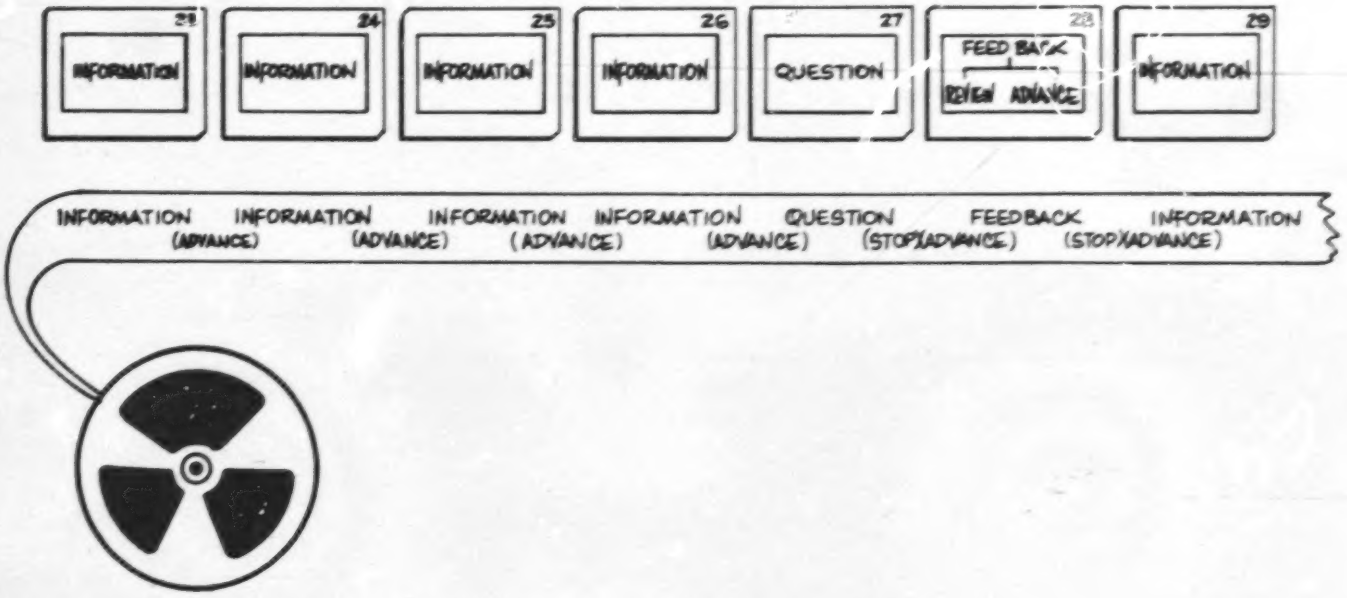

Figure 4. Format of sound-slide presentation format.

One remaining problem was to locate an audio playback unit that would be capable of reversing the slides while keeping the audio tract in synchronization. It was felt that this function was crucial to the success of the supplemental presentations since a strictly linear type of program with no review capabilities was inconsistent with the philosophy and goals of the project. At the time this decision was being made, the only available audio playback unit with review capabilities was manufactured by Telex Corporation of Minneapolis, Minnesota. Consequently all supplemental materials were developed around the capabilities of this machine.

An additional piece of equipment, a sophisticated slide production system, was purchased to add professional quality to the thousands of technical slides that are being developed.

These questions and problems having been resolved, a second workshop was organized in June of 1974, to train the twenty institutional instructors in the techniques of writing scripts for the supplemental sound-slide presentations. Each instructor was asked to pick one of the problem areas identified in the walk-through to develop an objective for a sound-slide presentation and to write a complete script. As in the modules, the material presented in the sound-slide presentations was introduced in small steps followed by a practice problem with immediate feedback.

Following the workshop, instructors were contracted to continue the script development. As with the modules, they were once again responsible for one edit of their scripts following a consultant's review. Remuneration was based on the recorded time of the script. A general rule of thumb was established to hold the length of each script to no more than twenty minutes; however, the principal criteria for length is the amount of explanation required to completely cover an objective.

As of mid-August, more than one hundred sound-slide presentations were in various stages of development. The overall goal of the project staff is to complete at least two hundred slide presentations before the termination of the project.

PROJECT EVALUATION

Simultaneously with sound-slide presentation and module development, the project staff is actively engaged in a complete evaluation of all the instructional material. To fulfill this objective, a Research Associate with a strong background in testing and measurement was hired in June 1975.

A third workshop for the consortium faculty members was held shortly after the Research Associate arrived in order to introduce the participating instructors to the evaluation plan and to develop the strategy for implementing the evaluation. A tentative listing of evaluation objectives include the following:

1. Do students learn more (or better) under the individually-paced curriculum than under conventional teaching methods?

2. An individually-paced curriculum may produce a very different grade distribution than that seen in a conventional course, as many more students may receive A's and B's in an individually-paced curriculum. Are these higher grades justified?

3. Does the "average" student in an individually-paced curriculum exhibit a significantly different long-term retention of facts and concepts than the "average" student in a lecture course?

4. Can the individually-paced curriculum materials developed by a given instructor be used in another institution with roughly equivalent results? That is, are well-written individually-paced curriculum courses relatively independent of who is the actual teacher, provided the teacher using them understands how the individually-paced curriculum works?

5. The majority of people who have taught self-paced courses have experienced the "procrastination problem" evidenced by a significant number of students who progress through the course at a rate much slower than average. What are the various causes of procrastination, and how may a course be designed to minimize the problem?

6. Connected with the fifth objective is the problem of dropouts. Self-paced courses regularly produce a higher dropout rate than other courses. Can this dropout percentage be reduced, and how?

7. What is the effect of class size? Does the quality of an individually-paced curriculum suffer as class size increases?

8. Do students under an individually-paced curriculum display a more positive affect toward subject matter than students under more conventional teaching methods?

The instructional material for each course will be tested by closely monitoring experimental and control groups. All eleven courses will be evaluated at various sites within the ten participating institutions during the three quarters of the 1975-1976 academic year.

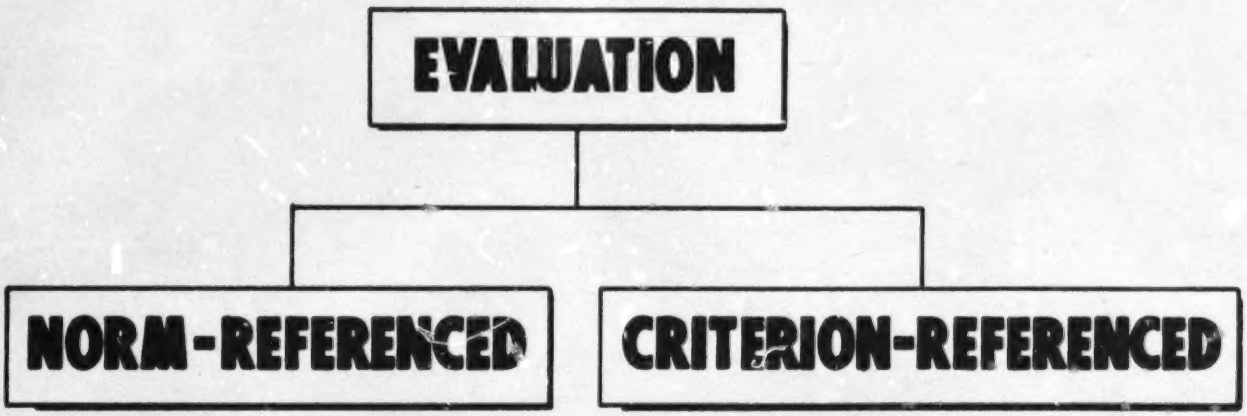

Figure 5. Evaluation emphasis.

As depicted in Figure 5, the evaluation will consist of a two-pronged approach: (1) a norm-referenced evaluation which compares the individually-paced curriculum with a lecture-based curriculum; and, (2) a criterion-referenced evaluation which determines the effectiveness of the individually-paced curriculum in respect to the pre-stated objectives.

For Further Information Contact:

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